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INTERDISCIPLINARY COMMUNICATIONS PROGRAM
• SMITHSONIAN INSTITUTION
1025 FIFTEENTH STREET, N.W. • SUITE 700 • WASHINGTON, D.C. 20005 • (202) 381-5577

M. C. SHELESNYAK, Ph.D., Director

Contract No. NSR-09-015-044

COMBINED QUARTERLY AND ANNUAL REPORT FOR PERIOD ENDING SEPTEMBER 30, 1969

A. Status of Conference Series:

1) Information and Control Processes in Living Systems --

The Fifth and closing Conference was held on February 23 to 26, 1969 at the Santa Ynez Inn, Pacific Palisades, California, under chairmanship of Dr. Otto Schmitt. List of participants and agenda, and copy of summary, are attached (Appendix A-1).

2) Biology of Hard Tissue --

The Fifth and closing Conference was held on March 9 to 12, 1969 at the Santa Ynez Inn, Pacific Palisades, California, under chairmanship of Dr. Marshall R. Urist. List of participants and agenda are attached (Appendix A-2).

3) Origins of Life --

The Third Conference, originally scheduled for May of 1969 and subsequently postponed, is now to be held on February 27 to March 2, 1970 at the Santa Ynez Inn, Pacific Palisades, California. Dr. N. Horowitz will be chairman. Particular attention will be focussed on information obtained from the Mars and Venus probes.

4) Population --

The Second Conference will take place on October 26 to 29, 1969, at Belmont, Elkridge, Maryland, under co-chairmanship of Sir Solly Zuckerman FRS and Dr. Hudson Hoagland. Population regulation will be emphasized, in particular fertility control by other than conventional family planning techniques. A summary of proceedings of the First Conference, held in September, 1968 is attached (Appendix A-3).

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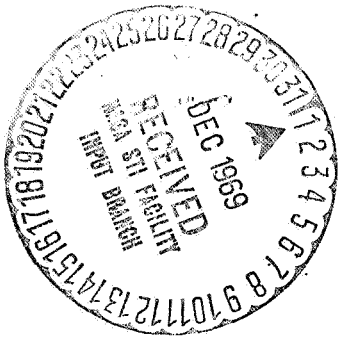

B. Status of Conference Planning:

1) The First Conference on Biosciences Applications of Space Science and Technology is being planned for November 23 to 26, 1969 at Belmont, Elkridge, Maryland.
Professor Joshua Lederberg will be chairman. The objective is to create a better appreciation and realization of the capabilities of the Space Program among:

(a) biologists and ecologists, particularly, concerned with pollution and the quality of the environment generally,

(b) biomedical and health service personnel, concerned with medical research, health services, hospital operation and patient care,

(c) various professionals concerned with development and utilization of technological augmentation of instruction: education and training.

2) The Third Conference on Population is expected to take place in late 1970.

3) Tentative planning has been done for two further conference series. One is on Solid State Dynamics and Biological Systems, and will derive from the earlier series on Biology of Hard Tissue. The other is on Models for a Biological Mathematics, and will be responsive to a need revealed in the series on Information and Control Processes in Living Systems. It now appears that,due to limited funding availabilities, initiation of these two series may be held over until a subsequent fiscal period.

In addition to the above formal conferences, a number of smaller, ad hoc meetings are contemplated in order to make preliminary investigation of additional subject matter and participants for possible future missions. One such meeting was held in May of 1969, directed toward the conference series on Space Biology.

C. Status of Publication of Conference Proceedings:

(For continuity, the information relevant to the preparation of manuscripts and to publication is cumulative, and includes the status changes during the contract period.)

Arrangements have been made with Gordon & Breach, Science Publishers, New York, to publish the proceedings of ICP conferences financed by the National Aeronautics and Space Administration. Promotion, sales and distribution responsibilities with regard to these volumes, as well as for previously published proceedings, have been assumed by the same

firm. It is anticipated that Interdisciplinary Communications Associates, Inc. may eventually take over publication responsibilities now being carried by ICP.

1) Information and Control Processes in Living Systems --

Scientific Editor: Dr. Diane M. Ramsey-Klee

(a) First Conference. Published under the title "Molecular Coding Problems" in 1967.

(b) Second Conference. All material has gone forward to the compositor. No date has yet been set for final release.

(c) Third Conference. Scientific editing is being completed by Dr. Ramsey-Klee.

(d) Fourth Conference. Master copy has been assembled, and is complete except for two revisions being awaited.

(e) Fifth Conference. Master copy is being assembled. Three revisions have not yet been received from participants.

It is planned that all conference proceedings will be published by the end of 1970.

2) Biology of Hard Tissue --

Scientific Editor: Dr. Ann M. Budy

(a) First Conference. Published in 1967.

(b) Second Conference. Edited by NASA; published by the G.P.O. in 1968.

(c) Third Conference. Last indices have been mailed to Gordon & Breach. Corrections are being completed for camera-ready copy. No date set for final publication.

(d) Fourth Conference. Letter has been mailed to Dr. Budy requesting information on manuscript. No answer received as yet.

(e) Fifth Conference. Master copy is nearing completion. Bernard and Glimcher revisions are still out; Glimcher's secretary called to say his would arrive soon.

It is planned that all conference proceedings will be published before the end of 1970.

3) Origins of Life --

Scientific Editor: Dr. Lynn Margulis

(a) First Conference. Has been withdrawn from Balaban in Israel, and from Gordon & Breach. Will all be taken care of from ICP end.

(b) Second Conference. Dr. Margulis is doing the scientific editing.

4) Population --

(a) First Conference. Books are scheduled from binders 8 October 1969.

D. Contract Administration

Continuation and renewal of the prime contract, to cover the period from October 1, 1968 to September 30, 1969 was finalized in February of 1969. Negotiations for continuation and renewal for the next fiscal period are now in process.

17 March 1969

FIFTH CONFERENCE ON INFORMATION AND CONTROL PROCESSES IN LIVING SYSTEMS

Santa Ynez Inn, Pacific Palisades, California
23-26 February 1969

Chairman - Doctor Otto H. Schmitt

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FIFTH CONFERENCE ON INFORMATION AND CONTROL PROCESSES IN LIVING SYSTEMS

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M. C. SHELESNYAK, Ph.D., Director
FRANK FREMONT-SMITH, M.D., Director Emeritus

FIFTH CONFERENCE ON INFORMATION AND CONTROL PROCESSES IN LIVING SYSTEMS

23-26 February 1969

Santa Ynez Inn
Pacific Palisades, California

Theme: Distributive Models

AGENDA

Conference will open on Sunday evening, 23 February, with dinner at 6:30 pm.

Welcome and Introduction - M. C. Shelesnyak

Introduction of Theme - O. H. Schmitt
Must Experiment Precede Theory? Our experiment in deliberate cooperative synthesis of a meaningfully quantitative framework of theory in which insight and experiment can grow.

Introduction of Participants

Morning Sessions	9:00 am - 12:30 pm
Afternoon Sessions	2:00 pm - 5:30 pm

Topics For Discussion : Monday Morning, 24 February	Discussion Initiators
Interpenetrating Domain Models of Distributive Information and Control Processes in Living Systems	O. H. Schmitt
Present Emphasis in Research on Information Processing in the Nervous System	K. N. Leibovic
Hierarchical Organization and Distributive Models	A. G. Wilson, E. O. Attinger

	Discussion Initiators
Monday Afternoon, 24 February	
Holographic Concepts and Transform Principles that suggest Models for Distributed Biological Information Processing and Control	J. Bigelow, H. El-Sum
Visual Pathways and Perception Models	K. N. Leibovic, W. A. Rushton
Tuesday Morning, 25 February	
The Possibility of Field-Type Communication between Molecules	W. F. Libby, M. Klein
Molecular Communication and Control	F. O. Schmitt
Tuesday Afternoon	
New Computers and their Programming to Process Adequately Distributive Information and Control Data	J. Macy, J. Milsum, J. Bigelow
Wednesday Morning, 26 February	
Synthesis: Theory we must create and experiments we must do to make distributed information and control processes understandable and computable	Schmitt

The development of distributive models of biological function and the consideration of hierarchical control mechanisms were the themes at the fifth of a series of conferences on information and control processes in living systems held in Pacific Palisades, California, 23–26 February 1969. The emphasis at this conference, as well as at other conferences in this series, was on creative discussion between members of different disciplines aimed at the development of significant new correlations or recognition of profitable future lines of inquiry in the area of information processing in the nervous system.

The conference began with a consideration by Otto H. Schmitt (University of Minnesota) of dispersive and interpenetrating domain models for information processing in the nervous system. He introduced the notion of a temporal-spatial representation as the dispersing variable in a distributed holographic model of the nervous system, a model which fits well with much of what is known about perception as well as the electrophysiology and neuroanatomy of the nervous system. K. Nicholas Leibovic (State University of New York, Buffalo) then cited the parallel development of progressively more complex sensory organs and brain structure as one moves up the phylogenetic tree. He suggested that the forces of evolution have produced a hierarchical control in complex nervous systems that permits subsystem autonomy for performance of routine functions.

The concept of hierarchical organization again appeared in the discussion by Albert G. Wilson (Douglas Advanced Research Laboratories, Huntington Beach, California) who presented a paradigm for ordering cosmic bodies in astronomy. He described three classes of hierarchical structures: (i) modular hierarchies wherein stable, semiautonomous modules aggregate into higher level modules which themselves serve as submodules for supermodular systems; (ii) control hierarchies; and (iii) polyarchies. By plotting the log mass of cosmic bodies versus their mass density (number of grams per centimeter), three natural, hierarchical levels are revealed. He suggested the possible applicability of such models of hierarchical organization found useful in astronomy to the study of control processes in living systems. Ernst O. Attinger (University of Virginia Hospital, Charlottesville) then presented evidence to support the existence of such a hierarchy of control in the mammalian oxygen transport system.

Hussein El-Sum (El-Sum Consultants, Atherton, California) introduced the discussion on holographic concepts and transform principles that suggest models for distributed biological information processing and control by presenting the conferees with a thorough exposition of the principles of holography.

Some interesting features that brain information processing and the physical phenomenon of holograms may have in common were developed. For example, one attractive feature of the hologram is its capability for massive storage of information. One can comfortably fit 10^5 bits of information in one plane and, considering all planes available in a film, can accommodate 10^9, or even 10^{12}, bits of information. Man has long been amazed at the great amount of data that the human brain can store, correlate and retrieve; thus, the hologram provides us with an excellent example of such data optimization. Another feature of the brain difficult to explain is its ability to use many different points of entry for the retrieval of a specific item of information. The hologram can reproduce an entire image by using just a piece of the original image in the reference wave; therefore, it too allows output of an entire information set using any point of entry. Still another point of analogy pertains to the ability of the brain to use both temporal and spatial referents for retrieving information. A challenge to the brain-hologram analogy was brought forward in response to data cited by one of the conferees on the strong temporal relation observed in recovery from memory loss by trauma, suggesting that memory scanning possibly has a temporal ordering. This was quickly resolved since the hologram likewise can be made using either a temporal or spatial reference.

In order for the brain to store the great amount of information that it does, it may be necessary for a single neuron to be a member of a number of different specific information sets of neurons. Given one neuron (A), it may be active in a certain memory set (X), or as a correlation circuit between memory X and Y, or even as a component of Y memory and X memory simultaneously. Likewise in the hologram any point on the film can be active in containing the information for different objects depending upon: (i) the storage of physical alterations at that point in the film induced by the reference wave, and (ii) its response to a particular reference wave in conjunction with all the points surrounding it. The essential feature here is the capability of using an individual point as an active part or carrier of many different information sets. One can change an object in an object beam and change the reference angle beam and so obtain multiple information on the same plate using the same points. A final feature of analogy between the brain and holograms is the Markovian factor or the distributivity feature inherent in the mathematics of both phenomena.

Objections were raised as to the efficacy of using the hologram as a model for the brain. One difficulty that arose was a comparison between the technical precision required in the construction and the retrieval of a hologram and the limits of technical precision that could be envisioned as operable within the constraint of brain structure as it is known. A further question arose concerning how temporal ordering could be accomplished in the brain using current knowledge of the function of neurons. An even more crucial difficulty in application of the hologram analogy is the requirement of fixed geometric positions in the hologram which has no counterpart in the fluid milieu of the brain.

Julian H. Bigelow (Institute for Advanced Study, Princeton, New Jersey) then reviewed the Longuet-Higgins model, which is an extension of holography techniques from light to sound (phonoholograms). The essential feature brought out in this discussion was that the exact geometry of the optical hologram, for instance, is not a fundamental requirement, but rather that many methods for the storage and recovery of information about both amplitude and phase (or their counterparts) might serve in analogous situations.

Willard F. Libby (University of California at Los Angeles) opened up the discussion on possible cell and molecular levels of interaction by examining the possibility of communication between molecules, for example, between the subunits of hemoglobin. The level of understanding of hemoglobin structure and the kinetics of association of the alpha and beta subunits into hemoglobin provided the opportunity for reflections on how the heme groups "communicate" with each other, such that when one heme has acquired an oxygen, the other does not have to pay the same price in free energy for acquiring an oxygen as did the first. Possibilities suggested were that electronic shift in the proteins attending the heme due to the first oxygen attachment lowered the required association energy for other hemes, or that the charged groups just outside of the heme

plates relaxed symmetrically due to heme polarization induced by oxygen attachment and thus lowered the initial entry energy barrier. William R. Carroll (National Institutes of Health) pointed out that the many subunits of glutamic acid dehydrogenase disassociate when steroid hormones are present, possibly because electronic shifts cause an entropy-based reconfiguration (steric shift). This association greatly affects the activity of the enzyme. He further pointed out that there are many such examples of "communication between molecules." However, two basic questions remained unresolved—if this kind of molecular interaction should indeed be called "communication" at all, and how such interaction could be active in information storage and transfer in the nervous system.

Melvin Klein (University of California, Berkeley) provided an added dimension to a possible molecular explanation of neuronal subsystem interactions by examining the role of liquid crystals (mesophases) as possible elements in molecular communication. The interchangeable smectic and nematic crystalline phases can order spontaneously, orienting in electric and magnetic fields into specific three-dimensional configurations. These dynamic structures then can be modulated chemically or thermally, and respond to subsequent mechanical stresses or electrical fields. It was pointed out that many biological molecules (DNA, RNA, and protein alphahelices) exhibit similar properties and that perhaps the brain might contain information in such dynamic geometrical structures which are continually being shifted and recorrelated by neuronal impulses. The question arose, however, how this information might be stored and accurately retrieved from what is known about brain tissue structure.

Francis O. Schmitt (Massachusetts Institute of Technology), in discussing the cell and molecular level of brain structure, noted that there exists much intercellular space in brain tissue filled with hyaluronic acid fibers, ions, and proteins, all packed into approximately 150-angstrom tubes. He speculated that there might be some analogy between the behavior of these molecules confined in small spaces and paracrystalline structures. These intercellular spaces are continuous in the brain, and hydration of their hyaluronic acid, with the association of water molecules, could effect ion movement by filling or ordering intercellular space. Another potential role that molecules might play in information processing in the nervous system could be facilitated by the differential movement of metabolites and gene products along the numerous microtubules and neural filaments of brain axons. The presence of different materials at synaptic junctions, controlled by electrical activity of neurons or feedback to the genome might provide a molecular rationale for specific neuronal interactions, and the establishment of dynamically interacting neural nets. The differential activity of microtubules, coupled with what is known of differential RNA synthesis, vesicle deposition at axon endings, and the principles of allosteric molecular recognition (ab-ag, enzyme-substrate interactions) all provide some circumstantial basis for the possibility of alteration of a building stone or structural unit of synaptic membranes which could serve adequately as a "recognition factor" between neurons of the same set. For example, the successful regeneration of the fibers from the optic tectum and their proper reconnection to the optic nerve would require such specific recognition.

Josiah Macy, Jr. (University of Alabama), in describing the components of a large hierarchical computing complex which serves a number of research laboratories, emphasized the problem of constructing indexing techniques to find stored information in computer memory. He drew an analogy to human information processing in the central nervous system and noted that present-day computer systems are not adequate to handle the massive amounts of data that the human brain is capable of storing and retrieving.

John H. Milsum (McGill University) characterized the ocularmotor control system as an open-loop system that has been optimized by evolution. When an organism's response to some aspect of its environment requires a consistent set of neural controls for survival, then the original open-loop neural pathway becomes a closed-loop, autonomous operation. He cited what appears to be the accretion of longer, more complex control pathways in the nervous system through evolution, followed by a "streamlining" of these control modes by bypassing certain unused portions of the pathways. He then noted the interesting possibility that certain mental pathologies might be interpreted as a reopening of these discarded pathways which should be bypassed for normal, adaptive behavior.

Julian H. Bigelow (Institute for Advanced Study, Princeton, New Jersey) drew together much of what had been discussed by sketching the beginnings of a model of neuronal behavior analogous to the functional properties of holography. In his model the precise geometric constraints necessary for recovery of information with holographic optics were replaced by the concept of distributed storage of information in the nervous system, recoverable en masse by sampling with "strobing" scans using precise timing. This model provides a mechanism for erasure of information by inverse cancellation and incorporates the requirement for a conformal mapping of neuronal activity in the brain over convoluted rather than planar areas.

The conference, chaired by Otto H. Schmitt (University of Minnesota), was organized under the auspices of the Interdisciplinary Communications Program, formerly of the New York Academy of Sciences and now of the Smithsonian Institution (M. C. Shelesnyak, director; Frank Fremont-Smith, director emeritus) and was supported by funds made available by NASA. An edited transcript of the proceedings is scheduled for publication.

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24 March 1969

FIFTH CONFERENCE ON BIOLOGY OF HARD TISSUE
Santa Ynez Inn, Pacific Palisades, California
March 9 - 12, 1969

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Co-Chairman: Doctor William F. Neuman

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24 III.1969

FIFTH CONFERENCE ON BIOLOGY OF HARD TISSUE
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FIFTH CONFERENCE ON BIOLOGY OF HARD TISSUE
- continued -

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M. C. SHELESNYAK, Ph.D., Director

FRANK FREMONT-SMITH, M.D., Director Emeritus

Santa Ynez Inn 9-12 March 1969

Fifth Conference on Biology of Hard Tissue

CONFERENCE THEME: OLD AND NEW PROBLEMS

AGENDA

Sunday, 9 March	6:30 p.m.	Cocktails and dinner
	8:30 p.m.	Welcoming remarks Self-introductions
Monday, 10 March	9:00 a.m.	Calcium Homeostasis R.V.Talmage - Discussion Initiator
	12:00 noon	Luncheon
	2:00 p.m.	Calcification and Ossification W.F.Neuman - Discussion Initiator
Tuesday, 11 March	9:00 a.m.	Calcification and Ossification - continued
	12:00 noon	Luncheon
	2:00 p.m.	Osteonecrosis G.C.H.Bauer - Discussion Initiator
Wednesday, 12 March	8:30 a.m.	Additional Topics and Prospectus M.R.Urist - Discussion Initiator
	1:30 p.m.	Luncheon

Coffee, tea, and cola will be served at convenient breaks (about 10:30 a.m. and 3:30 p.m.) in the morning and afternoon sessions. No formal sessions are planned for Monday or Tuesday evenings.

APPENDIX A-3

Reprinted from
24 January 1969, volume 163, pages 408-409

SCIENCE

Interdisciplinary Communications: Population

One might call it a midterm reappraisal. It is 20 years since the population problem demanded action programs and the prospect of 7 billion people by A.D. 2000 remains inescapably with us. To evaluate what has been achieved and what the prospects may be, the Interdisciplinary Communications Program of the New York Academy of Sciences and the Smithsonian Institution brought together representatives of demography, anthropology, economics, biomedicine, the law, business management, international relations, ecology, sociology, and programmers. The time-scale was the next 20 to 25 years.

T. W. Schultz (University of Chicago) professed his belief that in the next 20 to 25 years the world could feed the multiplying population. If the governments of the developing countries would modernize, which means abandoning a cheap food policy, they could maintain a dynamic economy and be able to take advantage of the modern advances in high-yielding crops. He admitted that it would not eliminate hunger nor produce the balanced diets which the nutritionists would want. It would mean a shift in the areas of food production. For example, in India the advantages of high yields would mean a shift to the Ganges Plains and the major rice bowls of the southern parts, at the expense of the large triangle of central India. Scores of millions of people who are dependent on agriculture reside in this large area of the Deccan, but the new superior varieties of rice, wheat, corn, millet, and others that are responsive to fertilizer are decisively less productive in this triangle because of lack of rainfall and water for irrigation. It would mean migration from this area to provide labor supply for the others. It was inescapably true that the modernization of agriculture could not be administered in such a way as to encourage the production of the optimum requirements of nutritious food. But it did reduce the requirements of land so that acreages would not be the limiting factor. High yields meant not only the intensive use of fertilizer but of pesticides. A danger lay in the vulnerability of the new strains to blight.

J. L. Fisher (Resources for the Future) similarly claimed that minerals, water, and fuel would not be a limiting factor in the next 20 to 25 years. Petroleum would continue to be the major source of power. Even if wells should show signs of depletion, there were vast reserves in the oil shales. New fields were being proved like that in Northern Alaska which, with pipelines, could supply up to 20 percent of the present consumption in the United States. The world outlook was hopeful. He did not see anything which could prevent a fivefold increase in energy supply. Nor were there any predictable shortages or cost increases in iron supplies. Copper, lead, and zinc were more problematical—but there were "outs" there by tricks of substitution. Water could be much more efficiently used. Only 5 percent was required for domestic use. The big losses were in mismanaged irrigation. In industry there would be much more recycling. The compelling reasons for population control were not the running out of resources. He was concerned about the social and biological effects of crowding and environmental damage.

K. Davis (University of California) reported preliminary findings in a world survey of urbanization. Already 38 percent of the world's population were living in urban places, of whom 22½ percent were in cities of 100,000 or over. By coincidence, this was the proportion in the United States in 1900.

The rate of change was remarkable. Ten percent of the world's population were already living in million-plus cities. In 1950, 161 million were so living and today the figure is 375 million. On present trends the whole population of the world would be living in cities of a million and over within 76 years—15,000,000,000—and there would be cities of 1.3 billion population. He stressed the absurdity of the figures.

One of his most telling points about the trends in urbanization in developing countries was the difference between the historic process in the United States and what was happening elsewhere today. The growth of American cities was produced by migration from rural areas. The growth in the cities in developing countries was mainly due to urban fertility and not to intake. The cities themselves were providing the new industrial labor. At the same time, the rural population was growing rapidly without being able to find work by migration to the cities. This meant that, unlike the pattern in the United States where the movement of rural population to become the industrial workers of the cities had compelled technological advance on the farms, the modernization of agriculture in the developing countries would be impeded. He foresaw great political dangers in the growth of the cities. Hunger and misery was obscured in the countryside. In the cities, they provided a common front. In the United States, urban unrest was traceable to the rapid growth of the cities where the planners were trying to solve the problems created by the solving of problems 6 years before.

R. Freedman (University of Michigan) reported on the evaluation of family planning programs in Asia. Not enough time had yet elapsed to judge success or failure. Although many governments had accepted the need for family planning 10 or 15 years ago, effectively the programs had been operating for much shorter times—in India, for only 3 years. He cited "good programs" in Taiwan, Korea, Hong Kong, Singapore, and Malaysia. There the birthrates were falling. In Taiwan, the birthrate was down from 40 in 1962 to below 25. In Singapore where, uniquely the program is based on The Pill and where 85 percent of the babies are born in one maternity hospital, the birthrate had dropped to 24. In Korea the birthrate was falling. It could be

ascribed to uterine devices, vasectomy, and illegal abortion.

S. J. Segal (Biomedical Division of the Population Council) reported on birth control methods at present in use or on clinical test. He estimated that between 12 to 15 million women in the world were using the pill and about 5 to 7 million were using intrauterine devices. There were still clinical reservations about oral contraceptives. There was concern about prediabetic symptoms in over one-third of the women. The effect of the steroids on the liver function could be serious when the nutritional level was low and where there was parasitic infestation. It was difficult to promote oral contraception mass campaigns in developing countries when the pill was still subject to medical prescription in the advanced countries.

M. C. Shelesnyak (Interdisciplinary Communications Program) called for more enterprise both in research and application. In no other field of pharmacology were the safety demands so exacting and indeed unreasonable—complete reliability of the method and no side-effects being expected. The population problem was so serious that some degree of calculated risk must be taken.

The discussions ranged over the effects of the rate of population increase not only on amenities but on the environmental necessities for survival, over the possible role of legislation in imposing either incentives or sanctions, and on communications. Here it was stressed that the levels of communication and persuasion from the educated elite to the person-to-person conversion did not conform to any global blueprint. Far more had to be known about the grass-root responses or nonresponses, because in this especially intimate question people were not going to be persuaded by either international or national imperatives.

S. Zuckerman (Chief Scientific Adviser to the U.K. Government), a specialist in reproduction physiology, pointed out that all the hormonal contraceptives, in use or in clinical evaluation, were based on physiological principles known in 1935. He urged that basic researches into human reproduction should be better supported, not just likely winners. He also urged that far more should be found out about the historical patterns of population change—like investigating parish registers in Europe. In the demographic field we needed far better information about birthrates and age distribution, not only for whole countries but for localities.

While Sir Solly accepted the fact that acreages would not be the limitation of food production and that in absolute terms there would be no desperate shortages of "hard resources" in the short term of 20 to 25 years, he foresaw grave complications in the social patterns which were considerably being determined by decisions now being taken. He cited the problems of the disposal of nuclear waste from installations being projected now. He pointed out the risks involved in the modernization of agriculture. This had to be highly capitalized and mechanized, but by intensification and localization crops became more vulnerable and liable to catastrophe. He stressed the point about reproduction in the cities now producing a labor force which would stifle migration from the countryside, while the high-yield areas would mean the virtual abandonment of the low-yield areas.

He contended that we could not decide what another generation would regard or accept as a way of life. The tendency seemed to be toward huddling together, by choice, in cities. Our responsibility was to avoid squandering resources and fouling up the amenities that the next generation might want to use. He accepted the likelihood of a rise before A.D. 2000 in mean temperature through human activities, with consequent climatic effects, and he recognized the dangers of pollution. The whole story of mankind was the adaptation of the environment. Were we producing a nonadaptable environment?

Speaking as a scientist who was concerned with practical politics, he said that there were no shortcuts to the solution of the population problem. It began with individuals. The individual had to be convinced that there was a problem. Then it had to be made societal, then political, then governmental, and then executive. Government action could only reinforce or facilitate initiatives which had already been taken.

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